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COMPLETE SPECIFICATION

Means for controlling Signal Level in Radio and Line Signalling Systems

We, AUTOMATIC ELECTRIC LABORATORIES, INC., a Corporation duly organised under the Laws of the State of Delaware, United States of America, of 1033, West Van Buren Street, Chicago, 7, State of Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to multiplex signalling systems of the carrier type. Further it is concerned particularly with improvements in operation of such systems at times when the transmission path between a transmitting point and a receiving point is subject to high intensity but variable noise conditions. Noise of this character tends to make communication either difficult or, under operations as now customarily established, intolerable, since the signal-to-noise ratio is so unfavorable.

As the invention will be described, it will be related for explanatory purposes to a radio communication channel between the point of transmission and the point of reception, although it is to be understood that the principle herein to be described and set forth are equally applicable to a wire line communication system, such as would be used for telephone, telegraphy or the like.

It is known that during conditions when the noise present on a communication channel increases, which, illustratively, would be where a radio circuit is in use and a signal fade occurs, the receiver automatic volume control raises substantially the receiver amplification by operating it with a higher gain. This, of itself, is desirable, but the general overall effect is that the noise present in the channel is also intensified, as it were, through amplification. It then is often a case where the signal-to-noise ratio is so unfavorable as to become intolerable for high quality operation.

The present invention operates upon a broad principle of sampling of the noise actually received and then utilising that sampled noise signal to exercise a control of the signal actually transmitted. In its operation the method and principle herein to be set forth will be found to function in such manner as to maintain the transmission level at such state as to provide for a continual generally constant signal-to-noise ratio over the complete circuit between the input serving to control the transmitter operation and the output derived from the system which output represents the final signal received and made useful at the output end of a receiver load circuit.

For the purpose of explaining the invention it may be assumed that the signalling system is of the carrier-telephone type. In these systems, the voice frequency telephone conversation usually can be considered as covering a band of modulation frequencies not exceeding 3,000 cycles, and usually somewhat less. In a system of this character, a considerable number of separate communications may be carried on concurrently by allotting the different conversations to different portions of a frequency band through the use of a multiplicity of subcarriers, equal in number to the number of separate communications which are to be carried out. Each separate sub-carrier is modulated by one telephone message, and all of the modulated sub-carriers concurrently modulate the outgoing carrier. Operations of this type sometimes involve the use of frequency modulation methods which, of themselves, are of known and established character; amplitude modulation may also be used.

Various types of carrier systems may be employed. The communications may be via a connecting wire line or a radio connecting link. The separate talking channels of any carrier system include many different fre-

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quency components existing simultaneously which may be appropriately separated at receiving points by way of appropriately selected filters, as is well known in the art. Accordingly, it is to be pointed out that the invention herein set forth is not, of itself, directed to the particular apparatus used either to generate the signals or to reproduce the signals, but, rather, the invention is directed to the overall system and the adoption therein of an appropriate means to overcome the damaging effect upon the desired signals which noise otherwise would introduce.

For purposes of consideration of the present invention, the communication channel between the point of transmission and the point of reception may be regarded generally as a "constant-equivalent circuit." A circuit of this type may be characterised as being one in which the amplitude of the signal available at the receiving point has a constant ratio to the amplitude of the same signal at the point of transmission. Thus, for these considerations, the circuit may be regarded as being one wherein the transmission can be regarded for reference purposes as being constant. The received signal may be at either a higher level than that transmitted (owing to intermediate amplification) or at a lower level, as is usually the case. So understood, therefore, the constant-equivalent circuit will be assumed to be one wherein there may or may not be an increase or decrease in the signal level from the point of transmission to the point of reception provided the circuit is of such characteristic transmission that any losses or gains, expressed in db, between the transmitting and the receiving points can be regarded as constant. Accordingly, any changes in the character of the signal arriving at the receiving point which cause it to vary in other than normal manner from that transmitted may be regarded as due only to noise variations.

Within the meaning of the present invention the circuit noise may be defined as any impulses not directly representative of the desired message. Such noise is due to various causes. The noise components include not only the random atmospheric disturbances which enter into the communication channel between the point of transmission and the point of reception but also include receiver thermal noises which are superimposed on and add to the ambient atmospheric noises.

Still further, in a communication channel of the type herein being considered there is also always present noise resulting from cross-talk and distortion. These latter components arise at the transmitter. For high quality transmission the total noise should be of the order of 60 db below the signal level. Under such circumstances conversion of the received signal energy into the usable form to evoke in the observer the sensation like that obtaining at the transmitter takes place in such a manner that the observer cannot distinguish the presence of noise in the signal actually reproduced.

The main differences between the consideration of the invention as applicable to a radio communication channel and a wire line communication channel rests in the fact that it is known that an increase in power of a 2:1 ratio (3db) on a radio link will increase the range of transmission by about 40%, whereas on a wire line, such as a standard 19-gauge cable, the losses can be calculated as being about 1 db per mile, so that a 2:1 increase in power in the case of cable transmission will only increase the range of transmission by about 3 miles.

In any type of transmission of this nature it is desirable that the signal output from the transmitter shall be such as to provide at the transmitting point a control which is instantaneously, or substantially so, varied in accordance with the conditions obtaining on the communication link between the transmitting and the receiving points. In this way, the transmitted signal level is maintained as a function of the noise actually present at the receiving point. To achieve this result, the noise present at the receiver is sampled and the sample caused to generate a control signal to be fed back from the receiving point to the transmitter point over a suitable control channel.

This may be a radio link or a wire line communication channel, such as is used for voice, telegraphy, telemetering or the like, depending on the nature of the system as a whole. At the transmitter point the so-transmitted signal is received and there used to regulate the transmitter power, the amplitude of the signal transmitter or to exercise other control to regulate the operation in the direction of establishing the maximum signal-to-noise relationship. Various forms of control instrumentalities may be used for this purpose and may include a variable amplifier or losser, a suitable arrangement to control the modulated power radiated from the transmitter, or the control may be through an appropriate signal-limiting operation.

Alternatively, the desired effect may be achieved by utilising at the transmitting point a combination of all three methods of control functioning either in unison or in sequence, or in any other desired relationship. These devices maintain the received signal level substantially constant, and so long as the power transmitted remains constant the circuit has a constant equivalent.

The carrier of the transmitter is modulated by a plurality of sub-carriers of different frequencies, and filters are provided at the

receiver for separating these sub-carriers after detection. The sub-carriers are amplitude modulated with the signals to be transmitted, and at the receiver are demodulated after separation.

It is to be understood that all commercial circuits of this character are designed with sufficient reserve power to maintain communication under the worst conditions that are normally to be expected. During about 90% of their operating time only a small fraction of their possible range of modulation is used. This is not only for reasons of economy of power, but also because transmitter noise increases with per cent. of modulation in more than linear proportion. Therefore, in ordinary operation of such circuits, the power is increased to maximum only during periods of bad fading or excessive atmospheric disturbance, such adjustment usually being made manually.

In using this invention on such a circuit, one sub-carrier (referred to hereinafter as the " pilot channel ") is transmitted unmodulated by any signal. As received, therefore, the only modulation on this sub-carrier is noise. Because circuit noise is known to be truly random, containing all frequencies in substantially equal proportion, the noise on the pilot channel is an accurate sample of that existing on the other channels of the circuit, its absolute magnitude being to that of the total noise on all of the channels together as the width of the pilot channel is to that of the sum of all the channels of the circuit.

The pilot channel carrier is filtered, the noise component is detected and in some cases passed through level-changers—i.e., amplifiers or attenuators—of the same character as those operating on the other channels of the circuit. The resultant of these operations, which may now be referred to as a " noise signal," is used to develop a control signal which is returned to the transmitting point through some suitable channel, e.g., an otherwise unused channel at the receiving-end transmitter if the system is two-way. At the transmitting point the noise signal is again detected and used to control the transmitter.

This control may be exercised in a number of ways. It may, through a level-changer, operate on the various signals before modulation to increase the percentage of modulation. It may, through similar means, vary the gain of a power amplifier to increase the transmitted power and it may be used to regulate automatic level control devices in the individual channels so that these devices will raise the average level of the signals at the expense of some reduction in the dynamic range of the signals. Preferably, all three of these expedients are employed.

Assuming that a circuit has been so designed that under normal operating conditions the signal-to-noise ratio is 60 db, with half of the noise contributed by transmitted distortion and the other half by the circuit and the receiver, this means that of the power in the received signal the noise component is one millionth that of the signal. If, now, owing to fading, increase of channel noise, or both, the signal level falls in relative value so that the overall signal to noise ratio is only 43 db, (20,000 to 1 power ratio) the contribution of the transmitter distortion to the total noise will be negligible, as it has remained a constant at the original 1/2,000,000 of the total transmitted power.

Under these conditions, assume that the modulation percentage of the transmitter be increased in accordance with this invention by 10 db. The percentage distortion at the transmitter will also be raised by about the same ratio, so that the transmitter component of the noise will be 20 db above its original level, and it becomes now only 43 db instead of 63 db below this level, again contributing one-half of the noise power. The signal power has, however, been increased by 10 db, so that the signal-to-noise ratio has been increased from 43 db to 50 db.

These figures are given only for purposes of explanation, as the actual gain in signal-to-noise ratio would be greater. The increased received power drops the receiver gain, through the operation of the automatic gain control. If the rise in signal-to-noise ratio is due primarily to fading, rather than atmospherics, the reduction in receiver gain will of itself decrease receiver noise in like proportion, so that balance will occur at a higher signal-to-noise ratio than that above given. Furthermore, where radiated power is also increased, a further gain in signal-to-noise ratio occurs which does not increase the percentage noise in the transmitted signal. Automatic level control prior to modulation introduces distortion noise only at the occasional peak levels, and therefore does not increase the transmitted noise ratio to the same extent as does increase in modulation. Therefore, where all three methods of control are employed, it is possible to keep the signal-to-noise ratio constant to within a few db, say to within from 3 to 6 db of the ratio at normal operating conditions. In terms of linear ratios this means that with a normal 60 db ratio the noise would rise from one millionth of the signal power to four millionths, whereas with the 40 db rise in noise level considered in the illustration given above the noise power in a conventional system would be one ten thousandth of that of the signal, a ratio twenty-five times as great. The employment of the invention therefore converts a constant-equivalent, variable noise system into what closely approaches a constant equiva-

lent, constant noise system.

Furthermore, the entire operation is automatic. The functions performed are those used in emergency by the operators of such systems in any event, but here they are performed substantially instantaneously to almost each change of condition, and much more effectively than is possible by intercommunication between operators at the two ends of the circuit and manual settings in accordance with interchanged instructions. There must, of course, be some slight degree of lag in the response of the system to make it sensitive to average noise rather than single unique bursts. The period over which the noise is integrated to obtain such average is a matter of engineering design, dependent in part on the specific system. Once this period is determined, it is necessary only that the final level control be slightly faster in operation than the transmitter response to assure satisfactory operation.

According to this invention, the signal sent out from the transmitting point to the receiving point is transmitted over substantially a constant equivalent circuit upon which different noise levels may be experienced at different times. An illustrative circuit of such type of circuit would be a long radio link including a frequency modulated transmitter and a receiver provided with automatic volume control, limiter, or, preferably, both.

From what has been above stated, it will be apparent that it becomes an object of this invention to provide for automatically controlling the signal-to-noise ratio over a transmission path wherein variable noise conditions exist.

Another object of the invention is to provide a control of the signal-to-noise ratio which will be effective in accordance with the amount of noise actually present at any particular time, which amount is a varying factor and therefore may be used to establish transmission levels in such a way as to regulate and obtain a constant transmission level.

Another object of the invention is to provide a control of the signal-to-noise ratio on a transmission path where there is improved stability of control obtained by reason of the fact that the conditions instantaneously obtaining are utilised to control the operation.

A further object of the invention is to provide for the operation of a communication channel wherein a plurality of messages are transmitted and wherein greater stability of operation is maintained and a usable signal-to-noise ratio is established at all times by increasing the transmission level during conditions of high noise intensity to a degree such that a substantially constant overall ratio of signal-to-noise is continuously maintained.

A further object of the invention is to provide in a carrier system an automatic control of the signal-to-noise ratio which operates as a function of the noise level, whereby at all times an optimum balance may be obtained.

Still a further object of the invention is to achieve the effect of a constant signal-to-noise ratio through the establishment of a control over the transmitter output power, the transmitter modulation percentage, the transmitter channel peak cutoff characteristic, or all of them, operating under the control of the noise component in a sampled signal or control frequency derived at the receiving end of the system.

Still other objects and advantages of the invention are those of controlling the operation of a carrier system of communication over either a radio or a wire line connecting channel in such a way that the functioning of the transmitter is such as to reflect the conditions of reception occurring at the receiving end of the system.

Still other objects of the invention will become apparent, when the following specification and claims are read in connection with the drawings illustrating in block diagram embodiments which the invention may assume. In the accompanying drawings,

Fig. 1 diagrammatically represents a control circuit by which the transmission level at the transmitting point may be established by samples of the signal received at a receiving point and

Fig. 2 represents in block form a modification of the circuit diagrammed in Fig. 1, and uses for control of the transmitter a connecting link between the receiver and transmitter, by which a suitable control frequency may be selected at the points of reception and supplied therefrom to the point of signal origin or of signal relay to control the transmitting conditions instantaneously in effect.

Now referring to the drawings for a further understanding of the invention, all of the signals representing the intelligence to be conveyed from one point to another are transmitted by way of a suitable transmitter 11 over the indicated communication channel 12 to a suitable receiving point, such as that designated by the block at 13. The transmitter proper may be of any form of carrier transmitter from which a plurality of signals is instantaneously transmitted, as is well known in the carrier art.

For purposes of simplification, the invention may be considered as applicable to a telephone carrier system of the type involving approximately twenty-four separate message channels capable of being in operation concurrently. In this form, the transmitter comprises the usual power amplifier, suitable oscillators, various sub-carrier generators and the like and the usual f-m modulators, none of which need to be explained. The

communication channel designated at 12 is, in the illustrated instance, shown as a radio link, although, as above noted, it can equally well be a cable connecting the points designated at 11 and 13.

At the transmitter end of the system, the various messages may be assumed to originate in the conventionally-designated carrier cable block 14. This, it will be understood includes a multiplicity of separate signal sources, each modulating a separate sub-carrier which, in turn, modulates the main transmitter carrier. The output signals from the carrier equipment 14, also of known character, are then supplied through suitable conductors to a variable amplifier or losser unit 15, in which the gain may suitably be controlled by a control signal applied through the conductor 16, later to be discussed in further detail.

Concurrently with transmission of the desired signal modulation originating in the carrier equipment 14, signals in the form of oscillations developed by a pilot oscillator 17 are transmitted. The oscillator 17 is of any suitable form to develop an oscillation frequency of substantially stabilized character, which may be applied as a modulation of the transmitter and sent out along with the modulated sub-carriers. The pilot frequency itself is effective as an additional unmodulated sub-carrier, which can be appropriately recovered at the receiving point.

At the receiver 13 all of the signals sent out from the transmitter 11 are passed through a suitable variable amplifier or losser, conventionally represented at 18. This usually is in the nature of an amplifier of any desired number of stages, whose gain can be varied as by a control of the automatic volume control variety. Within the meaning of what is herein to be set forth it will, however, be understood, as a matter of explaining the principles upon which the invention herein set forth operates, that the component 18 may be in the form of a variable losser as well as an amplifier. The amplifier so used is customarily a unit serving to transmit the received signals through to an appropriate form of utilisation circuit, such as the carrier receiver equipment which is conventionally represented by the block 22. This equipment normally includes channel filters, detectors for each channel, and cable terminal equipment.

Considering now the communication link between the transmitter 11 and the output of receiver 13, this is preferably a substantially constant-equivalent circuit in that there is a constant ratio (or even precise identity), as the case may be, between the signal transmitted and the signal actually received. Consequently, the only variable factor so far as this portion of the circuit is concerned is noise introduced between the transmitting point and the output of the receiver. Hence this portion of the circuit is a constant-equivalent circuit having variable noise characteristics, the constant equivalence being established by automatic volume control, limiter, or both incorporated in the receiver 13.

In the receiver operation, as noise in the received signal varies, that portion of the noise so received on the pilot channel is selected to be fed back to the transmitting terminal as a control signal which will operate to control the variable amplifier or losser 15. It will be understood that the noise so received may be due to atmospherics or " static," or it may be thermal noise arising in the receiver itself which becomes apparent owing to an automatic increase in the gain of the receiver compensating for a fading signal.

The diagrammatic showing of the various components hereinabove described is made because, of themselves, each component represents a known portion of a circuit. It is in the combination of these various components, one with another, that the invention resides.

In this form of the device the pilot signal, modulated only by noise, divides into two paths. One of these is through a level-changing device 18, pilot frequency filter 19, amplifier 20 and " noise-signal " detector 21. The detector develops a potential which is a direct function of the noise content and is fed back to control the gain or loss of the variable level-changer 18, decreasing the gain or increasing the loss with increase in noise level. This converts the circuit, considered from the output of the transmitter to the input of the filter 19, and hence also to the input of the carrier equipment 22, into a variable equivalent, constant noise circuit.

The second pilot signal path is through a filter 23. The signal may reach this filter either directly from the receiver via switch 24 and lead 25, or, with switch 24 in its other position, through the level-changer 18 and lead 26. The first-mentioned path gives the more positive control, the latter the more accurate. After passing the filter 23, the pilot signal, with its noise content, is sent back to the transmitting point through a channel 27. This is shown, for illustration, as a wire line, but it may equally well be a radio link, and in the system here described would probably be an otherwise unoccupied channel in a return circuit. If the latter is the case, the pilot signal is selected by a channel filter 28 of like characteristics to filter 23, re-amplified by an amplifier 29 and the noise signal recovered by a detector 30. The potential developed by the latter is fed to the variable level-changer 15 through lead 16 and thus controls the level of the transmitted signal.

As supplied to the device 15, however, the noise signal varies the gain or loss in the opposite direction from the variation produced by the similar device 18. but in the same ratio. The level-changer becomes, therefore, a variable-equivalent link in the circuit between the input carrier equipment 14 and the output carrier equipment 22, but as the variance is equal and opposite to that in the remainder of the circuit the overall result is a substantially constant equivalent, constant noise circuit, although it will be recognised that, as in all devices where feedback is employed to obtain a control, the constancy is approximate only. The approximation may, however, be made as close as necessary or desirable.

In the modification of the system set forth in diagrammatic form by Fig. 2, like parts of the system are designated by like numbers in so far as is possible, although, in some instances, parts which appear to be somewhat alike in each figure bear different identifying characteristics, due to slightly different functional relationships. With the modified showing of Fig. 2, the received carrier as picked up at the receiver unit 13 is sampled as before and the noise component on the pilot channel utilised to control the variable amplifier or losser 18, located between the receiver 13 proper and the carrier equipment 22. As was indicated in connection with the description of Fig. 1, a control of the variable amplifier or losser 18 will serve to maintain the effect of a constant noise level at the input to the carrier equipment. Consequently, when the signal-to-noise ratio increases from the pre-established value, the variable amplifier or losser 18 will operate to reduce the noise and at the same time reduce the signal level to the receiver carrier equipment.

In the showing of Fig. 2 the pilot signal from the oscillator 17 is passed through the variable amplifier or losser 15 and sent by transmitter 11 as before. The receiver 13 and variable amplifier or losser 18 are also substantially as in the case of Fig. 1. An additional amplifier 41 steps up the received power further and the portion of its output representative of the pilot signal and its noise modulation is selected by a noise filter 47, re-amplified by an amplifier 48 and finally, the noise component is detected by the rectifier or similar device 49 and used to control the variable amplifier or losser 18, reducing its output in proportion to the amplitude of the received noise.

The reduction in output of the level changer 18 is effective on all components of the signal, including, of course, the pilot frequency component. This latter component is selected by a very narrow band filter 43, the characteristics of which are such as practically to exclude the noise components modulated thereon. The filtered signal is transmitted back to the transmission point through a suiable channel 45, which, as before, is represented by a wire line but may be a channel on a radio link. At the transmitter point this signal is again passed through a filter 46 of similar narrow-band characteristics to filter 43, re-amplified by an amplifier 29 and thence fed to a detector 30 which develops a control voltage for regulating the transmission. In this case, it will be appreciated that the control voltage is inversely proportional to the noise, since increased noise results in decreased amplitude of the pilot sub-carrier at the output of amplifier 41.

That the control signal is an inverse function of the noise level instead of a direct function as in the case of the modification first described is of no moment either theoretically or practically, since the control exercised can be the same in both cases.

In the case of the modification illustrated in Fig. 2, the control potential derived from the detector 30 is used to operate a number of devices instead of merely effecting an increase or decrease in level in the signals passed through the level changer 15 and thus affecting the percentage of modulation of the transmitted power. This latter effect is utilised, the control potential being applied to the level changer 15 through lead 16 as before. Simultaneously, however, the same control potential is applied to a power control device 44. This may be a variable-gain device of well known type which operates upon a power amplifier within the transmitter subsequent to the modulation of the carrier. Under these circumstances, the device 15 varies the percentage modulation applied to the carrier, this modulation being effected at low level. After modulation, the only significant change in the signal is its change in amplitude as effected by the power amplifier. The gain in the latter, under control of the device 44, is varied by change in the control potential simultaneously with a like variation in the percentage in modulation. The intensity of the received signal varies in accordance with both of these two effects.

In addition to these direct functions the control potential is also applied to limiters 55 which are connected in each of the communication channels. Such limiters serve to cut off the dynamic range of the signals to be transmitted, and are customarily set so that speech peaks rise very materially above the average speech level before the limiting effect takes place. The effect of the control voltage, supplied to these limiters through lead 53, is to reduce the margin between the mean amplitude of the signals and the peak amplitude. This permits the average level of the modulating signals to be in-

creased without introducing into the transmitted signals distortions caused by over-modulation of the peaks. Distortion of a different type is, of course, introduced, but such distortion occurs only momentarily and is much less disturbing than that caused by over-modulation. The limiting of the peaks does not, of itself, serve to increase the signal-to-noise ratio in channel 12. It does, however, increase the range over which the device 15 may be permitted to operate by increasing the average percentage of modulation without increasing the percentage at the peaks.

While all of the functions at the transmitter which have thus been described are exercised by virtue of the detected amplitude of the pilot channel frequency, it will be observed that these effects are, in fact, secondary or derived effects from the noise signal selected by the filter 47 and detected by the detector or other rectifier 49. In conditions of unusually bad transmission, this primary control potential may also be used at the receiving end to reduce the effects of the noise remaining in the system after the controls at the transmitting end approach or have reached their limits. The output of all of the channels from the amplifier 41 is fed to conventional carrier equipment 60. This equipment feeds, in each of its output channels, a variable threshold device 59. Several types of such devices are well known, and all are operative to stop the transmission of all signals which are of less than a predetermined amplitude. Like the variable amplifiers or lossers which already have been mentioned, they operate in response to a control or bias voltage which sets this minimum amplitude or threshold. A portion of the voltage developed by the noise signal through detector 49 is fed to each of these variable threshold units. When the noise signal rises above the range through which the control can work and would consequently become annoying to listeners on the receiving ends of the communication channels, the excess voltage becomes effective upon these variable threshold devices to raise the minimum signals which they will pass. As a result, during periods when no actual message is being transmitted, as, for example, in the pauses between words or sentences, the variable threshold units act to suppress the noise. When actual signals are being transmitted, however, their amplitude is greater than the threshold value and they are therefore passed on to the listeners. At such times, the amplitude of the signals themselves is sufficient to mask the noise, and since the circuit is quiet during the pauses, the effect is as though the noise were much less than is actually the case.

What we claim is:—

1. Apparatus for receiving concomitantly transmitted unmodulated pilot and modulated message-carrier waves which comprises selecting apparatus for receiving the so-transmitted waves from transmission points, transducer apparatus to derive the message signals received, means to derive the pilot frequency from the received wave energy, and means for developing a signal from the derived pilot frequency for transmission back to the signal origin point as a control signal and for simultaneously controlling the level of receiver operations, said control signal being a function of said derived pilot frequency.

2. Apparatus as set forth in Claim 1, including a level-changing circuit, a pair of output circuits from the level-changing circuit, one of said output circuits including a receiver transducer, the other of said output circuits including a pilot frequency filter and a detector means to derive an output voltage which is a function of the signal noise, and means for controlling the level-changing circuit in accordance with variations in the locally developed voltage.

3. Apparatus as set forth in Claim 1, for controlling the signal-to-noise ratio in a carrier system having means for transmitting signals over a communication channel over which noise is variable and wherein the channel constitutes a substantially constant equivalent circuit, including means for receiving signal energy and noise over the constant equivalent communication channel, means for sampling the received signals to derive therefrom control voltages representative of the variable noise only on the said communication channel, means to feed back to the transmitting point a control signal varying as the instantly-received variable noise, means at the transmitting point to receive the noise representative signals developed at the receiving point and fed back to the transmitting point, and means to modify the signal transmission from the transmitting point to vary the transmission level as a function of noise at the receiving point.

4. Apparatus as set forth in Claim 3, including amplifier circuits connected to amplify the signals received at the receiving point and to transform the substantially constant equivalent variable noise communication channel when added thereto to a variable equivalent constant noise communication channel, a variable amplifier circuit at the transmitting point constituting a variable equivalent circuit to supply signals to the transmitter, said fed-back control signals controlling the variable amplifier of the transmitter from the receiving point to transform the complete communication channel including the variable transmitter amplifier, the communication channel between the transmitting and receiving point, and the receiver variable amplifier into a constant

equivalent constant noise circuit having a substantially constant signal-to-noise ratio.

5. The method of controlling a communication link between a transmitting station and a receiving station which comprises the steps of simultaneously transmitting a modulated message-carrier wave and an unmodulated pilot wave from the transmitting station, detecting the pilot wave at the receiving station to derive therefrom a signal of an amplitude which is a measure of modulation imposed thereon by noise-generating factors along the communication link, generating a control carrier wave at the receiving station, modulating the control carrier wave with the derived signal, transmitting the control carrier wave so modulated back to the transmitting station and controlling the energy carried by the modulation of the message wave as a direct function of the signal amplitude.

6. The method in accordance with Claim 5, wherein the energy carried by the modulation of the message-carrier wave is controlled by varying the percentage of modulation of the message wave.

7. The method in accordance with Claim 5, wherein the energy carried by the modulation of the message-carrier wave is controlled by varying the amplitude thereof.

8. The method in accordance with Claim 5, wherein the energy carried by the modulation of the message-carrier wave is controlled by simultaneously varying the percentage of modulation and the amplitude thereof.

9. The method in accordance with Claim 5, which includes the additional step of limiting the signal modulation of the message-carrier wave under the control of the detected pilot wave.

For the Applicant,
FRANK B. DEHN & CO.,
Chartered Patent Agents,
Kingsway House, 103, Kingsway,
London, W.C.2.

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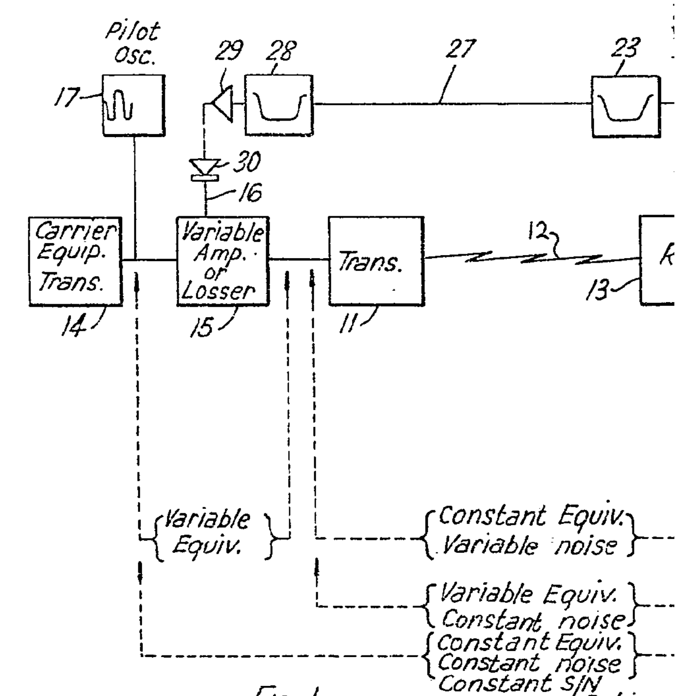
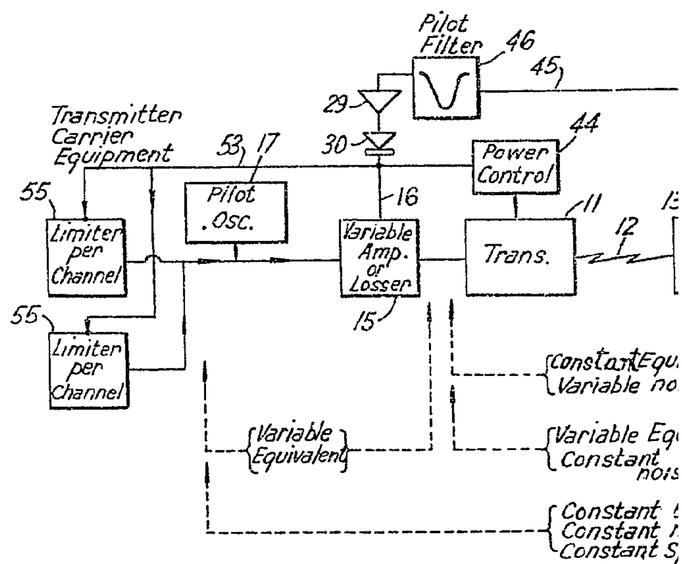


Pilot Osc.
17
29
28
27
23
30
16
Carrier Equip. Trans.
Variable Amp. or Losser
Trans.
12
13
14
15
11
Variable Equiv.
Constant Equiv. Variable noise
Variable Equiv. Constant noise
Constant Equiv. Constant noise Constant S/N Ratio

Fig. 1.



Pilot Filter
46
45
29
30
Transmitter Carrier Equipment
53
17
Power Control
44
55
Limiter per Channel
Pilot Osc.
16
11
Variable Amp. or Losser
Trans.
12
15
Variable Equivalent

Fig. 2.

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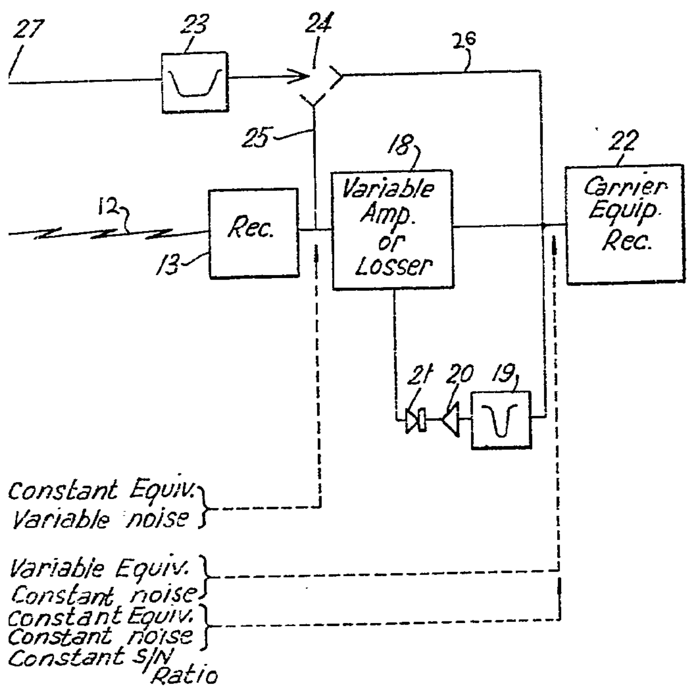

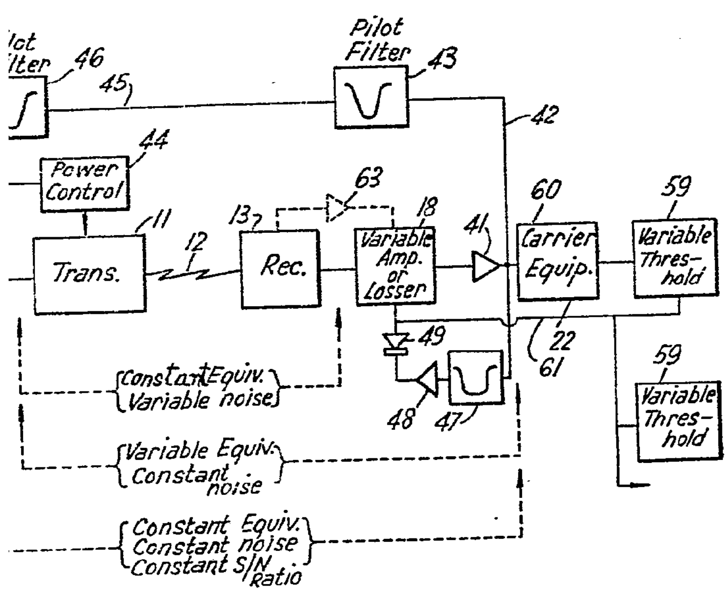

Fig. 2.

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1 SHEET
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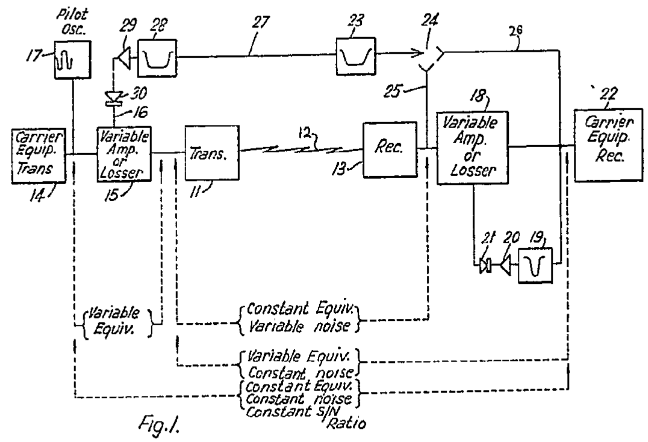

Fig.1.

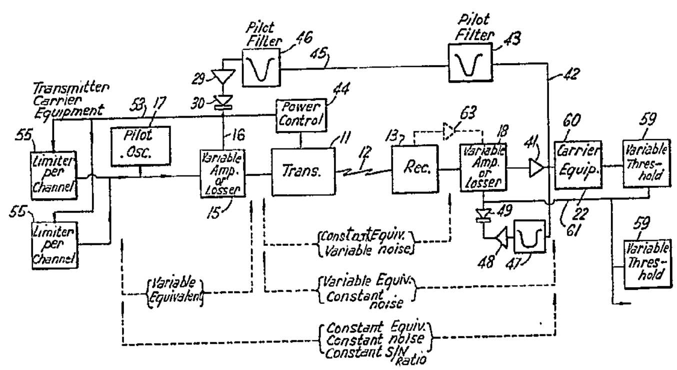

Fig.2.